PAUL SCHERRER INSTITUT

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20. September 2005

Specifications and Call for Tender for

Shielding Components of the SLS Beamline X12SA
for coherent Small Angle X-Ray Scattering (cSAXS)

1. Shielded Optics Hutch	X12SA-OP
2. Shielded Experiments Hutch	X12SA-ES
3. Pumping Chamber Shielding	X12SA-PCS
4. Hard X-Ray Pipe Shielding	X12SA-BGT

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1 Project Overview

The Swiss Light Source (SLS) is a 2.4 GeV, 400 mA electron storage ring, operated at the Paul Scherrer Institute (PSI) in Villigen, Switzerland. The SLS started its operation in summer 2001 with currently 7 beamlines that are open for users. One of the next beamlines to be built is the facility for Coherent Small Angle X-Ray Scattering (cSAXS). It is being build by PSI for an international user community. The beamline will be state of the art for challenging SAXS experiments on a routine basis, and provide potential to develop novel coherent SAXS techniques. The application ranges from industrial relevant topics over biological issues to fundamental problems in condensed matter physics. The design of the front end, optics, and shielded hutches will be based on that of the existing Protein Crystallography beamline X10SA.

A schematic layout of the beamline X12SA is shown in drawing 0-30040.65.009. The beamline will be located in a short straight section (X12S). A minigap, in-vacuum undulator serves as radiation source and will provide high-brightness X-rays in the energy range 5 to ~20 keV. At a distance of 12100 mm from the undulator, a beam-splitting mirror divides the beam into a hard X-ray and a soft X-ray branch. The front end includes SLS standard radiation safety equipment as well as an aperture system to reduce Bremsstrahlung and the total radiation power. These apertures in the front end define the maximal angular extension of the hard X-ray photon beam to 0.3 mrad horizontally and 0.1 mrad vertically.

At a distance of 28275 mm from the undulator, the hard X-rays will be energy filtered by a double-crystal monochromator. This fixed-exit monochromator will be equipped with Si(111) crystals with the second crystal being sagittally bent for horizontal focussing of the X-ray beam. Vertical focussing is achieved by means of a bent mirror, which is located in the vacuum chamber following the monochromator. A Bremsstrahlung stop is necessary to protect the downstream equipment.

During operation of the SLS, the shielded hutches and beam-pipe sections will provide radiation protection to users, whose main place of work will be in unshielded control hutches located adjacent to the optics and experiment hutches (X12SA-OP and X12SA-ES) as well as all persons on the hall floor.

2 Summary

This specification applies to two shielded hutches (X12SA-OP and X12SA-ES), a shielding wall for the pumping chamber outside the tunnel wall (X12SA-PCS) and a shielded tunnel for the transfer pipe between pumping chamber and optics hutch (X12SA-BGT). The items are illustrated in figure 1 and drawing 0-30040.65.009. All items are to be designed and fabricated by the Contractor according to the design 'A1' of the European Synchrotron Radiation Facility (ESRF), where applicable, or alternative PSI design, using lead (Pb) as shielding material.

The items shall be delivered to PSI in pieces, to be assembled on site by the Contractor.

Pre-construction surveying and post-installation radiation testing will be performed by PSI staff accompanied by Contractor representatives.

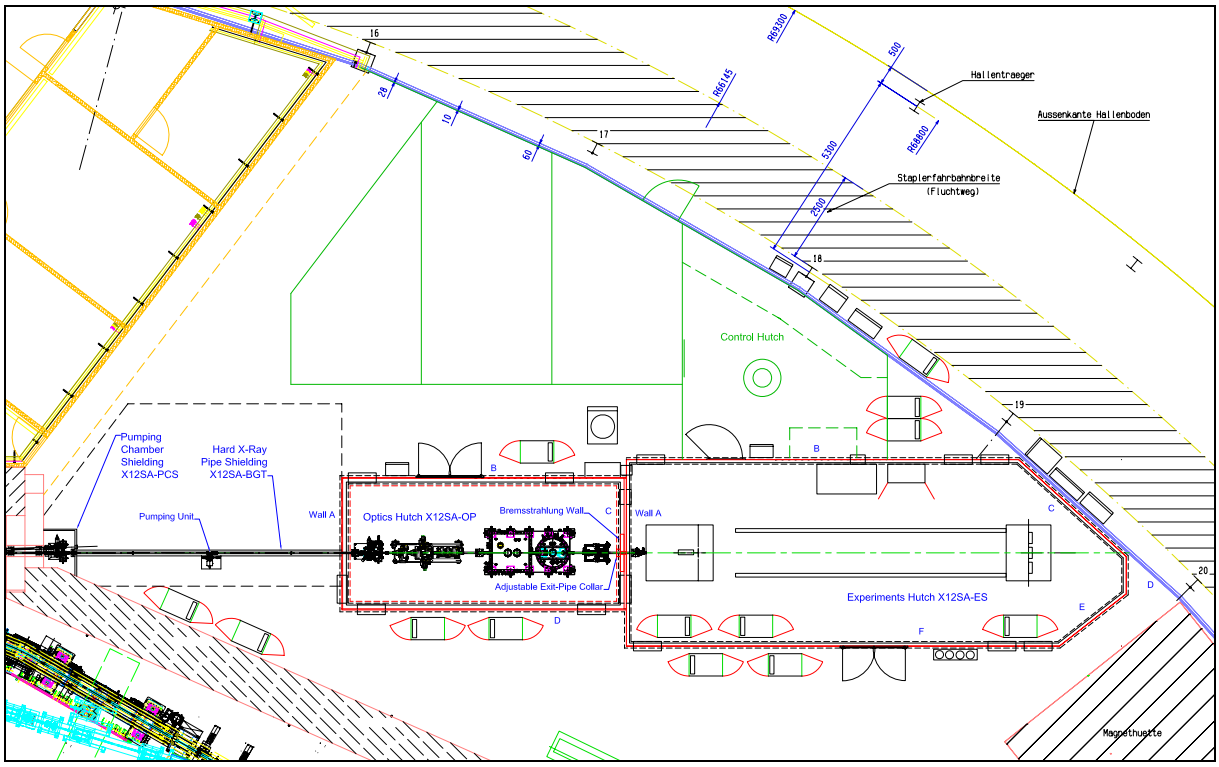

Fig. 1: Beamline overview with shielding components.

3 Specifications

In this document, the terms “left” and “right” refer to the sides as seen in beam direction, if not otherwise noted.

3.1 The SLS Experiments Hall

The following represents technical information on the SLS experiments hall and tunnel shielding of which the Tenderer shall take due account in his offer.

An overview of the beamline X12SA is given in drawing 0-30040.65.009. The floor of the experiments hall is 38 cm of reinforced concrete, with short- and long-term Young’s modules of 30 and 10 GPa, respectively, and a compression strength of 25 MPa, covered with a 2 cm thick cement layer. The maximum permissible load on the floor by a vehicle is 10 tons/wheel. Creating trenches or large holes in the floor is strictly forbidden, but drilled holes up to 20 mm in diameter and 150 mm in depth are permitted. The floor is specified to be flat to within ±4 mm over a distance of 20 m; however measurements have revealed local deviations as large as ±10 mm over 5 m. The temperature in the hall will vary in the range 22 to 28 ºC from winter to summer.

During the hutch design phase, PSI will draw up accurate survey data of the profile of the floor beneath the hutch walls. As far as possible, the Contractor shall avoid placing hutch pillars on slab joints. It is the responsibility of the Contractor to have a representative visit the SLS site during the design phase to discuss and agree on all aspects of the survey.

In this document and its appended drawings, all beam heights given refer to the SLS coordinate system zero level. In the final design, the Contractor shall take into account the level deviations of the floor given in the survey data for all relevant items (position of beam-pipe penetrations in hutch walls and shieldings, height of beam pipe supports, etc.).

3.2 General Requirements

3.2.1 Radiation Tightness

Radiation tightness at the joints of the panel structure, doors, windows, chicanes, penetrations, junctions between the hutch and the concrete floor slab and walls, and junctions between the roof and the walls of the hutches, is the most important aspect of this work, and must receive the Contractor's special attention. The methods of manufacturing shall be adapted such that the result conforms to specifications. The manufacturing tolerances shall in no way give rise to leaks. The PSI safety group will carry out radiation tests during commissioning of the beamline. A Contractor representative has to be present during these tests. **Any leak above 0.5 µSv/h (at a nominal current of 400 mA) found during the radiation test shall be repaired at the Contractor's expense.**

3.2.2 Design

All components are to be made of steel and lead construction, in first order conforming to the ESRF design 'A1', dated 12. March 1999, for which permission has been obtained from the director of the ESRF. The detailed specifications include pertinent descriptions of features such as wall and roof panels and joints, hinged doors, lead-glass windows, support of fluids and cable trays, as well as various chicanes and tube shieldings. This information is proprietary to the ESRF and cannot be made available to third parties nor used by the Contractor in other construction projects without express, written permission of the ESRF. Where appropriate, alternative designs approved by PSI shall be used.

Tenderers are requested to comment upon the specification and are encouraged to make alternative proposals to PSI in addition to the quotation for the given specification.

During the design phase, there may be small changes of dimensions and location of shieldings and chicanes.

3.2.3 Materials

3.2.3.1 Lead

All lead (Pb) parts produced shall have a minimum density of 11.3 g/cm^3. They shall be free of visible cracks and holes and free of grease, oil or any other slippery substance. Lead glass windows must have an equivalent lead thickness at least equal to the specified wall thickness.

The given lead thickness values are *minimum* thicknesses.

Attention shall be paid by the Contractor to all lead parts assemblies, in order to guarantee full contact between pieces. The lead parts shall not be damaged, hammered or otherwise spoiled before or during assembly.

It is strictly forbidden to perform welds not clearly indicated on the drawings approved by PSI during the design phase. Welds which are not easily accessible after assembly shall be checked with ultrasound before assembly in order to guarantee the minimum specified lead thickness.

3.2.3.2 Steel

All steel and welding materials shall have a minimum yield strength of 230 MPa. The Contractor shall provide the corresponding certificates.

All steel parts shall have the following corrosion protection: Frames of wall panels and roof elements, roof frame and ground frame shall be cleaned, sand-blasted and coated with zinc primer. Steel panels, doors, chicanes, cover joint profiles and all steel lining sheets shall be made from electro zinc sheets (class 1, two faces, 2.5 microns, degreased, passivated and phosphatized).

3.2.3.3 Glue

The Contractor shall provide PSI with the specification of any glue he intends to use. A quality control procedure for bonding lead and steel shall be defined, to achieve long-term stability of the bond in a radiation environment.

3.2.4 Assembly

The lead/steel panel units intended for walls and roofs shall be made in single pieces, with neither welding nor assembly on site.

The Contractor shall deliver to PSI the pre-fabricated items and shall assemble them on site. He is requested to provide a time schedule for the assembly. This schedule should indicate the intended usage of the large overhead hall crane (maximum load = 16 tons).

Radiation tests of the assembled shieldings will be performed in presence of a Contractor representative.

3.2.5 Provisions for Alignment

While designing, the Contractor should keep in mind that alignment markers will be installed by PSI close to the beam trajectory on the concrete floor.

Inside the hutches, holding plates for alignment purposes (size: 110 mm height, 70 mm width) may be installed by PSI at the back and front walls of the hutches above the beam trajectory in a height of approx. 2 m from the floor.

3.3 Specific Requirements for the Shielded Hutches X12SA-OP and X12SA-ES

3.3.1 Common Features for both hutches

Conventions for this document and its appended drawings:

Hutch walls are named starting with A for the wall through which the beam enters, then clockwise around the hutch center.

Hutch dimensions and floor areas given are from floor to inside lead roof, or inside lead walls, including steel lining sheets, if not specified differently.

The hutch roofs are to be removable with the overhead hall crane to allow the installation of heavy equipment.

3.3.1.1 Doors and Chicanes

The hutches include standard features such as single- and double-hinged doors, several types of chicanes for media and cables, single- and double-stranded LN_2 transfer lines, ventilation entrance and exit chicanes, and penetrations for the beam pipe. For cables and media hoses, a common chicane with parallel covers and an opening of 650 mm width and 100 mm height shall be used (ESRF 00.65.1156). The experiment chicanes have a typical penetration of 250 x 80 mm and feature a key lock (ESRF 00.65.1171). These standard chicanes are located at a height of 1500 mm above floor. The design of the door hinges should prevent the door from sliding down due to its own weight. The Contractor shall quote windows for all doors as an option.

3.3.1.2 Internal Crane

The hutches should have their own crane with a load capacity of 5 kN each, moving on rails along the entire length of the hutch (see ESRF drawings 00.65.1161, 00.65.1198). Manual operation of the crane shall be quoted as standard, electric operation as an option.

3.3.1.3 Air Conditioning

The shielded hutches will be air conditioned using cold water, brought in and out in pipes through chicanes to cool an internal air circulation, and an additional air stream that is brought in and out through ventilation chicanes. The ESRF “ventilation entrance chicane” and “ventilation exit chicane” (see drawings ESRF 00.65.1164 and 00.65.1201) shall be used for in- and outlet. They are to be mounted on the roofs or high on the walls, respectively. Within the hutches, the cooled air will be distributed by cloth tubes (250 mm in diameter), which are suspended either from the roof or from stretched horizontal wires. The air cooling system requires free space of 500 mm between roof and crane guide.

3.3.1.4 Support Provisions

The Contractor should provide support for media hoses and cable trays inside and outside of the shielded hutches, using Jordahl JM K 48/26 C-rails, or equivalent. They shall extend from floor to roof at approx. 1000 mm separation from each other.

The shielded hutches share walls with unshielded control hutches (to be fabricated using a wood-glaswool sandwich construction). The C-rails on the exterior of the shielded hutch walls will partly be used to support the roofs of the unshielded hutches.

3.3.2 Optics Hutch X12SA-OP

3.3.2.1 Size and Shieldings

The optics hutch X12SA-OP is shown in drawing 0-30040.65.009. The hutch has a height of 3600 mm and consists of 4 walls, making four 90° corners. The floor area of the hutch is 26.5 m^2.

There is a significant amount of Bremsstrahlung that must be blocked to fulfill the radiation requirements. Shielding calculations have shown, that Pb thicknesses shown in the following table are required:

Lead thicknesses for Optics Hutch X12SA-OP	
Wall	**Pb Thickness**
A	20 mm
B	20 mm
C	60 mm
D	30 mm
Roof	10 mm

The Pb lining on the concrete floor to protect from scattered radiation between floor and wall panels shall have a width of 200 mm

If the Pb lining extending into the hutch is covered with steel sheets, they shall adapt to the floor at a 30° angle.

The wall penetrations for the beam pipe shall have a diameter of 80 mm. The beam height at its entry on wall A is 1400 mm, at the exit on wall C 1460 mm.

To further stop the Bremsstrahlung beam in the forward direction, a succession of additional shielding is mounted to the inner side of wall C:

Bremsstrahlung Shieldings for Optics Hutch X12SA-OP	
Shielding	**Comment**
Bremsstrahlung Wall	100 mm thick Bremsstrahlung wall of approx. 1 m x 1 m, to be integrated into the panel structure of wall C and covered with steel. The central hole of diam. 80 mm shall be located at the nominal beam position. The design has to assure that there are no radiation leaks between the Bremsstrahlung wall and wall C.
Adjustable Exit-Pipe Collar	100 mm thick Pb shielding, 200x200 mm around beam pipe. Made of ten 10 mm thick, centrally split Pb plates with central hole of diam. 45 mm for a CF-40 beam pipe (O.D. 42.4 mm). Plate pairs stacked with their gap oriented alternating horizontal and vertical. The collar needs to be adjustable in height by +/- 20 mm around its nominal height.

3.3.2.2 Doors and Chicanes

The following components are needed in X12SA-OP. The air conditioning unit is located close to front wall A.

Doors and Chicanes for Optics Hutch X12SA-OP		
Qy.	**Component**	**Ref. Design**
5	Electrics and media chicanes on wall A, B, and D	ESRF 00.65.1156
1	Media chicane for fluids and gases on wall C, penetrating to the ES hutch	ESRF 00.65.1156
1	Experiments chicane on wall C, penetrating to the ES	ESRF 00.65.1171
1	LN_2 chicane for double-stranded transfer line on side wall B	PSI 2-30040.36.318
1	Double-wing hinged door with removable sill (1500 width x 2100 mm height) on wall B.	ESRF 00.65.1160
1	Tubular ventilation inlet on the roof close to wall A	ESRF 00.65.1164
1	Ventilation outlet, high on wall A	ESRF 00.65.1201

3.3.3 Experiments Hutch X12SA-ES

3.3.3.1 Size and Shieldings

The experiments hutch X12SA-ES is shown in drawing 0-30040.65.009. The hutch has a height of 3600 mm and consists of 6 walls, making two 90° corners and four non-90° corners. The floor area of the hutch is 62 m^2.

The required lead thickness for the walls and roof of X12SA-ES is 2 mm.

The Pb lining on the floor shall have a width of 150 mm

The penetration for the beam pipe on wall A shall have a diameter of 80 mm at a height of 1460 mm.

3.3.3.2 Doors and Chicanes

X12SA-ES has one single-wing hinged door on wall B. This door allows the entrance from the control hutch and represents the main door for the access control (LAC). It shall have a free width of 900 mm. Another double-wing door is located on wall F. This entrance is used to bring large equipment into the hutch. The air conditioning unit is located close to back wall D.

Doors and Chicanes for Experiments Hutch X12SA-ES		
Qy.	**Component**	**Ref. Design**
6	Electrics and media chicanes on wall B and F	ESRF 00.65.1156
1	Experiment chicane on wall B	ESRF 00.65.1171
1	Experiment chicane on wall A, penetrating to the OP hutch	ESRF 00.65.1171
1	LN_2 chicane for single-stranded transfer line on wall A	ESRF 00.65.1156
1	Media chicane on wall A, penetrating to OP hutch	ESRF 00.65.1156
1	Tubular ventilation inlet, located on the roof close to wall D	ESRF 00.65.1164
1	Ventilation outlet, located high on wall F, close to wall A	ESRF 00.65.1201
1	Single-wing hinged door of 900 mm width and 2100 height on wall B	ESRF 00.65.1160
1	Double-wing hinged door with removable sill (1500 mm x 2100 mm) on wall F	ESRF 00.65.1160

3.4 Specific Requirements for the Pumping Chamber Shielding X12SA-PCS

The Pumping Chamber Shielding X12SA-PCS shall provide radiation shielding for the chamber A31 and its associated components at the exit of the beam from the storage ring tunnel (drawings 0-30040.65.002a, 0-30040.65.011). The lead shielding shall extend 500 mm above and below the beam height of 1400 mm. To the right and back side, the shielding walls need to connect to the ring walls made of concrete. In beam direction, it should cover the vacuum shutters (A32/A32b), but leave two bores of diam. 80 mm for the hard and soft X-ray branch. The left bore for the soft X-ray branch should be closed by a removable stopper with the same amount of lead as for the wall, since the port will be used at a later stage. The left panel shall be easy to remove for quick access to the components.

The lead thickness to be used is 50 mm for the panel in beam direction and 35 mm for the left panel.

For the hard X-ray branch, a Bremsstrahlung pipe collar shall be forseen at the inside of the front wall. It consists of two lead plates, 200 mm square, thickness 50 mm each, and a bore of 80 mm diam. The plates shall be mountable individually, according to radiation requirements. See also drawing 3-30040.65.010.

The unshielded areas (top and sides) shall be covered by a grid as grasp protection. For easy future modification, the design of the shielding shall be modular. If radiation testing proves negative, it may have to be extended with a roof, and side panels extending to the floor.

3.5 Specific Requirements for the Hard X-Ray Pipe Shielding X12SA-BGT

The pipe shielding X12SA-BGT shall provide adjustable support and radiation shielding of the CF-40 vacuum tube which runs for a length of approx. 8 m at a height of 1400 mm from the Pumping Chamber Shielding X12SA-PCS to the Optics Hutch X12SA-OP (components A34 to A39 in drawing 0-30040.65.011). It shall provide radiation-tight connections to the neighbouring shieldings, and the tunnel cross section must be larger than the bore for the hard x-ray pipe in the Pumping Chamber Shielding PCS (see above). The design shall provide support and full cover of the intermediate pumping unit (component A36 and associated). ESRF reference designs 00.65.1163 and 00.65.1166.

The lead thickness of the shielding tunnel shall respect the recommendations in P. Berkvens' report, chapter "Tube shielding of the hard X-ray pipe…".

On a later stage, components for a soft X-ray beamline will be placed to the left, but very close to the hard X-ray vacuum pipe depicted in the drawings. The shielding tunnel shall therefore be designed with minimum space requirement, especially to the left side of the beam, providing a cover as close as possible to the vacuum pipe (CF-40 flange O.D. 69.5 mm). The solution shall employ a modular design and allow for easy future modification.

The vacuum pipe supports on the base of the shielded tunnel shall provide ample, though precise and stable adjustment vertically and left/right to the beam. The O.D. of the pipe is 42.4 mm.

4 Deliverables

4.1 Design Phase

The design phase is to be completed within 4 weeks of the placement of the order. The following items shall be delivered to PSI by this time:

1. A time and manpower schedule of all activities covered by the contract.
2. The quality assurance documents for all activities covered by the contract.
3. The list of operations to be performed in the factory prior to delivery of the units to PSI.
4. A report containing lists and detailed descriptions of components, materials and suppliers or subcontractors.
5. A complete list of the quantities of components, materials, etc. to be purchased by the Contractor to build the hutch.
6. All drawings used in the manufacturing of the shielded hutches in printed and electronic form according PSI Specification AN-94-02-02. The drawings will become the property of PSI, and PSI (by agreement with the ESRF) will have free use of them.
7. Calculations on the mechanical stability of the hutch structure and the load on the experiments hall floor.

4.2 Manufacturing Phase

All items the specifications in chapter 3 apply to are to be delivered:

1. Shielded Optics Hutch X12SA-OP
2. Shielded Experiments Hutch X12SA-ES
3. Pumping Chamber Shielding X12SA-PCS
4. Hard X-Ray Pipe Shielding X12SA-BGT

5 Quality Control

The Contractor shall certify that he operates under a quality assurance system that complies with the ISO 9002 or an equivalent national standard. The requirements of PSI for quality assurance are stipulated in the specification ESRF/ENG/89/02 "Quality assurance requirements" from 12/9/1989.

The manufacturing phase shall not begin without written approval of PSI, covering both engineering and radiation safety aspects. The Contractor shall give PSI two weeks advance notice of the completion of the design phase.

PSI reserves the right to visit the Contractor, upon reasonable prior notice, to review progress of the manufacturing process.

The Contractor shall notify PSI immediately for review and approval of any design changes, fabrication discrepancies, changes in documented schedules or other commitments according to this specification and all terms of the purchase order.

6 Packing and Shipping

The Contractor is responsible for packing and shipping to the SLS site of all parts necessary for the assembly of the hutches. Adequate packing and protection must be provided to prevent damage during transport. Packing cases shall be non-returnable. The maximum weight of each individual case is 1500 kg. PSI shall be notified prior to shipping of any piece exceeding this weight.

The shipping address for all items of this Call for Tender is:

Paul Scherrer Institut
Warenannahme
CH-5232 Villigen PSI
Attention: Xavier Donath

Besides the shipping address, the following is to be displayed clearly on the outside of the packaging:

- The PSI contract number
- The weight of the loaded package
- Support points for transportation and lifting, as well as the location of the centre of gravity

7 Tentative Time Schedule

Deadline for Quotes	30. November 2005
Signing of Contract	15. December 2005
Finalized Design following Joint Design Meeting	31. January 2005
Setup at PSI finished	31. May 2006

The joint design meeting will take place at PSI.

8 Appended Documents and References

8.1 List of Appended Documents

8.1.1 Drawings

- 0-30040.65.009 X12SA Shieldings Layout
- 3-30040.65.010 X12SA-PCS (Pumping Chamber Shielding) Layout
- 2-30040.36.318 X06SA LN_2 Chicane
- 0-30040.65.002a X12SA Front-End Overview
- 0-30040.65.011 X12SA Front-End Component Layout

8.1.2 Documents

- P. Berkvens: Shielding Calculations for the cSAXS Beamline. 3. July 2005

8.2 References

Documents reffered to but not attached to this specification. PSI will supply these upon Contrators request.

- PSI AN-94-02-02: Technical Drawings and their Delivery by External Suppliers
- ESRF Safety Hutches Design ‘A1’ (detailed specification), dated 12. March 1999
- ESRF Technical Services Division: Quality Requirements. ESRF/ENG/89/02.
- ESRF Standard Hutches Drawings:
  - 00.65.1145 Location of items
  - 00.65.1146 Door sill
  - 00.65.1147 Alignment & survey penetrations
  - 00.65.1148 General cross section
  - 00.65.1149 Panels mounting sequence
  - 00.65.1150 Wall panels elements
  - 00.65.1151 Wall panels elements for doors
  - 00.65.1152 Cover profiles
  - 00.65.1153 Roof elements
  - 00.65.1154 Window in panel walls
  - 00.65.1155 Window in door
  - 00.65.1156 Fluids chicane

00.65.1157 Electrical chicane
00.65.1158 Ventilation chicane
00.65.1159 Chicanes cutouts
00.65.1160 Doors cross sections
00.65.1161 Service loads on hutch
00.65.1162 Doors details
00.65.1163 Tunnel tube shielding
00.65.1164 Tubular ventilation exit chicane
00.65.1165 Lead profiles
00.65.1166 Shell tube shielding
00.65.1167 liquid nitrogen chicane
00.65.1168 Bremsstrahlung wall
00.65.1169 HLS Chicane
00.65.1170 Liason to concrete wall
00.65.1171 Experiment electrical chicane
00.65.1192 Wall panels elements
00.65.1193 Panel elements for doors
00.65.1194 Cover profiles
00.65.1195 Roof elements
00.65.1196 Liaison to concrete walls
00.65.1197 Joints
00.65.1198 Service in hutch 3400
00.65.1201 Ventilation entrance chicane
00.65.1202 Panels mounting sequence